Place attachment and walking behaviour: mediation by perceived neighbourhood walkability

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Abstract

The environmental features of a location are important for facilitating people's attachment to places. Attachment to particular places, such as residential neighbourhoods, may encourage people to adopt and maintain physical activity routines. Moreover, the ways in which people perceive the built features in their neighbourhood (e.g., walkability) may mediate the relations between place attachment and physical activity. Therefore, this exploratory study examined the associations between place attachment and neighbourhood-specific physical activity and explored the extent to which perceived neighbourhood walkability mediates these associations. The study included survey data from 1,800 adults living in Calgary, Canada. Place attachment (including identity and dependence), physical activity, and neighbourhood walkability were self-reported using validated tools. Linear and logistic regression models were applied to estimate the associations between variables. Mediation was assessed using structural equation modelling. Place attachment dimensions were significantly positively associated ($p < 0.05$) with weekly participation (odds) and time spent walking for transport and recreation. The associations between place attachment and walking for transport were also mediated by perceived neighbourhood walkability. Together, these findings emphasise the crucial role of place attachment, particularly human bonding and relationships with the neighbourhood environment (i.e., place attachment), in supporting physically active lifestyles.

Keywords: urban design, place dependence, place identity, walking, walkable environment

1. Introduction

Physical activity confers various health and well-being benefits (World Health Organization, 2019). Notably, physical activity is recognised as a sustainable behaviour contributing to the United Nations' sustainable development goals (Nigg and Nigg, 2021). Physical activity is shaped by several personal, family, social, and built environmental aspects (Sallis et al., 2015). Therefore, cognitive and contextual factors likely affect how individuals perceive their daily activities and interactions with their surrounding environments may influence physical activity decision-making. Place attachment, in particular, may influence and can be influenced by cognitions and interactions with environments and is associated with outdoor physical activity (Kyle et al., 2004; Lee and Shen, 2013; Nursyamsiah and Setiawan, 2023; Tsaur et al., 2014; Yuan and Wu, 2021). For instance, a recent study conducted in China found a positive link between place attachment and outdoor leisure activities (Yuan and Wu, 2021). Another study conducted in Indonesia found that place attachment had a positive effect on revisiting a renovated park (Nursyamsiah and Setiawan, 2023).

Place attachment builds through the interaction between humans and places and reflects an individual's affective, emotional, and functional connection with particular places or settings (Low and Altman, 1992; Williams and Roggenbuck, 1989). Over time, the human-environment interaction leads to assigning value and meaning to a geographical space, becoming recognised as a place (Tuan, 1977). Conceptual and empirical support suggests that place attachment includes at least two related dimensions, including "place identity" and "place dependence" (Jorgenson, 2016; Kyle et al., 2005; Moore and Graefe, 1994; Williams and Roggenbuck, 1989; Williams and Vaske, 2003). The two dimensions of place attachment, while being moderately correlated, show evidence of divergent validity (Bakar et al., 2016; Bricker and Kerstetter,

2000; Kyle et al., 2003). Moore and Graefe (1994) suggest that place dependence may contribute to place identity. Most studies to date support the existence of place identity and place dependence as dimensions of place attachment; however, some support for other facets of place attachment also exists (i.e. social bonding, affective bonding, lifestyle factors (Kyle et al., 2005; Kyle et al., 2004). Place identity reflects the centrality of a place or setting in the person's life (McIntyre and Pigram, 1992). Symbolic and emotional meanings, rules, regulations, norms, behavioural intentions, attitudes, beliefs, and knowledge inherent in using a place contribute to forming a place identity (Low and Altman, 1992).

Place dependence is the second important dimension of place attachment. Place dependence reflects the reliance on a location to perform preferred activities or behaviours (Moore and Graefe, 1994; Scannell and Gifford, 2010; Stokols and Shumaker, 1981). For example, Kyle et al. (2004) found that respondents were dependent on metropolitan parks for health-related benefits (i.e., reducing tension, relaxing physically, and getting exercise). Place dependence is typically linked with the ability to undertake specific behaviours within specific settings, as exemplified in the following quotes offered by participants in previous studies, "Hiking here [Appalachian Trail] is more important than hiking in any other space" (Kyle et al., 2005) or links general behaviour with specific settings (i.e. "The things I do on this trail I would enjoy just as much at another trail"; (Moore and Scott, 2003). In addition, tools used to measure place dependence include items that capture the suitability and substitutability for undertaking desired activities in other settings compared with the setting of interest.

Several environmental features and characteristics are essential for encouraging people to become attached to places and forming their place attachment (Adewale et al., 2020; Chang et

al., 2023; Eisenhauer et al., 2000; Sun et al., 2020). For instance, a study conducted in Nigeria found that improving housing quality and security was supportive of residents' place attachment (Adewale et al., 2020). Another recent study conducted in China found that housing conditions were positively associated with place dependence (Chang et al., 2023). Place attachment can also affect a person's evaluation or perception of their external environment (Lewicka, 2011; Liu et al., 2020). In line with the nudge/behavioural insights (Hallsworth and Kirkman, 2020; Thaler and Sunstein, 2009), both perceptions and the presence of external built environmental features, especially those found in residential neighbourhoods, have been shown to correlate with physical activity (Jáuregui et al., 2016; Liao et al., 2018). Notably, residential neighbourhoods are places where people devote much of their time and often perform much of their physical activity (Frehlich et al., 2018b; Moudon et al., 2006). There has been a growing number of studies examining the effects of the built environment on physical activity (Elshahat et al., 2020; Kärmeniemi et al., 2018; Stappers et al., 2018; Tcymbal et al., 2020). For instance, a systematic review of longitudinal studies and natural experiments found that several built environment changes such as improving the accessibility to destinations and increasing the land use mix were supportive of active behaviours (Kärmeniemi et al., 2018). These studies used both perceived and objective measures of the built environment in relation to physical activity. For example, a study in the US found that higher perceived neighbourhood walkability was positively associated with higher odds of engaging in sufficient physical activity among adults (Wang et al., 2023). Another study in Taiwan found that the objective availability of sidewalks (calculated by geographic information systems) was associated with daily step counts in the elderly (Chen et al., 2019). Thus, perceived neighbourhood walkability may be one of the environmental factors contributing to forming a place attachment (van den Berg et al., 2022). It is also plausible that the effects of place attachment on physical activity might be mediated through perceived neighbourhood attributes (e.g., walkability). Those with stronger

place attachment may have more positive perceptions regarding their neighbourhood's built environment and therefore more likely to participate in physical activity. While there appears to be evidence linking both place attachment and perceived walkability with physical activity, and both result from cognitive processes, to our knowledge, no study has investigated both variables within a single analysis within the context of determining physical activity.

Therefore, this exploratory study has two aims: 1) to examine the associations between the place attachment dimensions and neighbourhood-specific physical activity among a sample of Canadian adults, and 2) to explore to what extent that perceived neighbourhood walkability mediates these associations. Figure 1 shows the conceptual framework informing this study. The study hypotheses are as follows: (a) higher place attachment (including identity and dependence) is associated with neighbourhood-specific walking for transport and recreation, and (b) perceived neighbourhood walkability mediates these associations.

INSERT FIGURE 1 ABOUT HERE

2. Methods

2.1. Participant recruitment

Data from a sample of Calgary (Canada) residents were used in this study. The full details of the study design have been previously reported (McCormack et al., 2012; McCormack et al., 2010) and are available as Supplementary information. In brief, adult participants were randomly selected (n=4422) from landline telephone numbers in 2007 and 2008. Of these,

2006 completed a follow-up postal survey. These surveys obtained physical activity behaviours, place attachment, perceptions of neighbourhood walkability, and sociodemographic information. The University of Calgary Conjoint Health Research Ethics Board approved this study (REB# 20798).

2.2. Measures

Neighbourhood physical activity. A modified version of the International Physical Activity Questionnaire (IPAQ) questionnaire (Craig et al., 2003), named the neighbourhood-specific IPAQ (N-IPAQ), obtained participants' frequency and usual minutes of walking for transport, walking for recreation, and vigorous physical activity (VIGPA) during the last seven days inside their neighbourhood (an area within 10 to 15-minute walking distance from home). VIGPA was included for comparative purposes because it captures recreational physical activities other than walking and is less consistently associated with the neighbourhood built environment relative to walking (Wendel-Vos et al., 2007). The reliability and validity of this questionnaire in Canadian adults have been reported elsewhere (Frehlich et al., 2018a; Frehlich et al., 2018b). Consistent with previous studies (Cerin et al., 2006), outlier values were truncated at the 99th percentile of our sample. The weekly duration of walking for transport, recreation, and VIGPA were calculated for each participant. To reflect participation (i.e., none versus any), binary outcomes for each physical activity variable were calculated using a cut-off of 10 minutes/week (Cerin et al., 2006).

Place attachment. Informed by previous work (Williams and Vaske, 2003), two dimensions of place attachment, including place identity and place dependence, were assessed. Place identity and place dependence were assessed by six items (see Table 1) that captured

participants' level of agreement regarding their relationship with their neighbourhood (an area within 10 to 15-minute walking distance from home). The mean scores of place identity and place dependence were computed by dividing the sum of the item scores by the number of items completed for each subscale (to account for and retain those with incomplete items). Most participants responded to all place identity (99.5%) and place dependence (98.8%) items. An overall score for place attachment was also estimated by dividing the sum of all twelve items by the number of completed items. The Cronbach's alpha of place identity, place dependence, and place attachment scales were 0.92, 0.79, and 0.90, respectively. Further, test-retest reliability was acceptable for the place identity, place dependence, and place attachment scores, with intraclass correlation coefficients (ICC) of 0.89, 0.74, and 0.88, respectively.

INSERT TABLE 1 ABOUT HERE

Perceived neighbourhood walkability. Participants' perceptions of neighbourhood walkability within a 15-minute walk from home were captured by the Abbreviated Neighbourhood Walkability Scale (NEWS-A) (Cerin et al., 2009; Leslie et al., 2005). The NEWS-A questionnaire obtains residents' perceptions of their surrounding neighbourhood environment attributes supporting walking. These attributes are land use mix diversity, access to services, street connectivity, pedestrian infrastructure, safety, and neighbourhood aesthetics. The full details can be found elsewhere (McCormack et al., 2013). Participants scored neighbourhood walkability items on a four-point Likert scale from strongly disagree to strongly agree. Neighbourhood perceived walkability was calculated by dividing the sum of these items by the number of completed items. Higher scores for all perceived variables reflected better

perceived supportiveness of the neighbourhood environment for walking behaviour. The Cronbach's alpha of the scale was 0.87. Among a Canadian sample, moderate test-retest reliability was found for most of these items (McCormack et al., 2013).

Covariates. Several sociodemographic variables, including age, gender, educational level, annual gross household income, marital status, number of children at home, and self-rated health, were obtained and included as covariates in all models. We also included the length of residence as a covariate because the time spent in a place may be associated with the development of the place attachment (Suminski et al., 2005).

2.3. Statistical Analysis

Descriptive statistics were calculated for covariates, physical activity variables, and perceived walkability. The distributions for the three physical activity duration variables were positively skewed; therefore, we applied natural log transformations to improve each distribution. Covariate-adjusted generalised linear models (Gaussian distribution with identity link function) estimated the associations of the place attachment dimensions (identity and dependence) with the duration of walking for transport, recreation, and VIGPA (path c – total effect). Structural equation modelling (SEM) was used to test the mediation effects of perceived neighbourhood walkability in these associations. We used the post-estimation "medsem" package in Stata (Mehmetoglu, 2018) to identify mediation following Zhao et al.'s recommendations (Zhao et al., 2010). Based on this analysis, the type of mediation effect was determined (i.e., no, partial, or full). The statistical significance of the indirect effects (path a × path b) was tested using the Monte Carlo simulation (5000 replications) to address the limitations of the Sobel test (Mehmetoglu, 2018). The relative magnitude of the mediation

effect was presented as a percentage and calculated based on the ratio of the indirect (path a × path b) to the total effect (path c) (Mehmetoglu, 2018). Multivariate logistic regression models (both with and without perceived walkability as a covariate) were undertaken to estimate the odds of ratios (ORs) and 95% confidence intervals (CIs) for the association between each place attachment dimension, and any walking for transport, walking for recreation, and VIGPA (≥10 minutes/week). Since our missing data was low (5%), we used a complete-case analysis (Jakobsen et al., 2017). We analysed the data using Stata 15.0 (Stata Corp., College Station, TX, USA), and the significance level was $p < 0.05$.

3. Results

3.1. Sample characteristics

Data from 1800 participants were analysed. The mean age was 50.2 years, and 62.7% were female, 44.8% had completed a university degree, 30.1% had an annual gross household income lower than $60 000/year, 69.8% were married or living together, 66.1 had no children at home, and 44.0% reported very good or excellent health status. The mean of residence was 12.8 years. Participants reported an average of 1.8, 2.7, and 2.5 weekly hour of walking for transport, recreation, and VIGPA, respectively (Table 2).

INSERT TABLE 2 ABOUT HERE

3.2. Place attachment, perceived walkability, and neighbourhood physical activity duration

The associations between place attachment and physical activity outcomes are shown in Table 3. Place identity was significantly positively associated with walking for recreation (b=0.11, 95% CI 0.03, 0.20, $p = 0.011$). There were significant positive associations between place dependence and walking for transport (b=0.17, 95% CI 0.05, 0.30, $p = 0.006$) and recreation (b=0.24, 95% CI 0.14, 0.34, $p < 0.001$). Place attachment (overall) was also positively associated with walking for transport (b=0.14, 95% CI 0.01, 0.27, $p = 0.038$) and recreation (b=0.23, 95% CI 0.13, 0.34, $p < 0.001$).

The mediation effects of perceived neighbourhood walkability for associations between place attachment variables and physical activity outcomes are shown in Table 3. The indirect effects of place identity, place dependence, and place attachment (overall) on walking for transport through perceived neighbourhood walkability were significant (b=0.04, 95% CI 0.01, 0.07, $p = 0.014$; b=0.02, 95% CI 0.00, 0.05, $p = 0.040$; and b=0.04, 95% CI 0.01, 0.07, $p = 0.026$, respectively) (Table 3). There were full mediation effects of perceived neighbourhood walkability in the associations between place identity (57%) and place attachment (27%) with walking for transport. A partial mediation of perceived neighbourhood walkability was also detected between place dependence (14%) and walking for transport.

INSERT TABLE 3 ABOUT HERE

3.3. Place attachment, perceived walkability, and neighbourhood physical activity participation

Table 4 shows the estimated associations between the place attachment dimensions and perceived walkability with the odds of undertaking any neighbourhood walking for transport, recreation, and VIGPA. There were significant positive associations between place attachment dimensions and odds of any walking and physical activity. The odds ratios for these associations attenuated but remained statistically significant even after entering perceived neighbourhood walkability in the models.

4. Discussion

The first aim of our study was to estimate the associations between place attachment dimensions and walking and physical activity. Place attachment dimensions were significantly associated with higher duration and odds of walking for transport and recreation within neighbourhoods. A few previous papers have indirectly explored the relationship between place attachment and physical activity, primarily focused on leisure activities (Kyle et al., 2004; Lee and Shen, 2013; Tsaur et al., 2014). For instance, Lee and Shen (2013) found that place attachment was positively related to destination loyalty among dog walkers in urban parks. Our findings support these studies and extend them by examining walking for transport and recreation in relation to place attachment. There were no significant associations between place attachment and duration of VIGPA. This is supported by the fact that our measure of VIGPA is non-context specific and may be undertaken outside the neighbourhood. Moreover, relative to walking, the neighbourhood built environment is less consistently associated with VIGPA (Wendel-Vos et al., 2007). VIGPA behaviours (e.g., cycling, running, sports) may also require high motivation. Highly-motivated individuals may perceive fewer barriers and be willing to travel further than the usual boundary of the neighbourhood to reach recreational destinations (McCormack et al., 2006). Therefore, the

duration of VIGPA is likely less influenced by a neighbourhood's walkability and people's attachment to their neighbourhood. Nevertheless, place attachment and perceived walkability were associated with participation in (i.e., doing any versus none) VIGPA. Regardless of the duration of physical activity, getting people to engage in physical activity is also essential in promoting their health and well-being. The mechanisms of these associations are largely unknown. One of the few previous studies examined the associations between objective and perceived walkability with place attachment. They found that perceived walkability was positively associated with place attachment through the pathway of social interactions (van den Berg et al., 2022).

The second aim was to evaluate the mediation effect of perceived neighbourhood walkability in the association between place attachment and walking. Previous studies demonstrate that people's evaluations and perceptions of their surrounding environment can be influenced by the place attachment (Lewicka, 2011). Notably, we found that perceived neighbourhood walkability mediated the associations between place attachment and walking for transport. Our study is the first to test this mediated pathway formally; thus, there are no other studies with which we could directly compare our findings. Nevertheless, the link between place attachment and neighbourhood perceptions has been investigated in previous studies (Lewicka, 2011; Özkan and Yilmaz, 2019; van den Berg et al., 2022). For instance, a study found that residents satisfied with the levels of neighbourhood pollution (i.e., noise and air), criminal activity, and the quality of public open space were more likely to take pride in their neighbourhood (Mesch and Manor, 1998). The same study also found that those satisfied with the quality of public open space and the level of criminal activity would be more likely to feel remorse if they moved out of their neighbourhood. Another study found that perceived incivilities and crime were negatively associated with place attachment (Brown et al., 2003).

There is consistent evidence linking perceived walkability with physical activity, including walking for transport (Hanibuchi et al., 2015; Nichani et al., 2019; Wang et al., 2023). For instance, a study conducted in Canada found that perceived neighbourhood walkability was associated with higher participation and time spent in different physical activities (Nichani et al., 2019). Another study in the US found that better perceived land use mix and street connectivity were associated with accelerometer-based physical activity (Carlson et al., 2018). Our findings suggest that place attachment could support active transportation-related behaviours by enhancing residents' walkability perception. There were no mediation effects in the relationships between place attachment and walking for recreation. Compared with walking for recreation, walking for transport appears to depend more on the neighbourhood's built attributes (Farkas et al., 2019; McCormack and Shiell, 2011). Future studies should consider exploring other pathways through which place attachment may influence walking for recreation.

Our findings emphasise the importance of place attachment in supporting physically active lifestyles, particularly human bonding and relationships with the neighbourhood environment (i.e., place attachment). Time living in the neighbourhood may support the place attachment (Smaldone, 2007). There may be factors that encourage people to remain in their neighbourhoods for extended periods, for example, a person's "residential satisfaction". This residential satisfaction likely reflects a person's preferences and their preferences being met by the neighbourhood (i.e., matching) (Hillcoat-Nallétamby and Ogg, 2014; Wang et al., 2019). The supportiveness of the built environment would need to match people's preferences, and thus in terms of the causal pathway, actual (objective) attributes of the built environment may precede place attachment. It has been shown that objective and perceived built environment measures do not correspond (Koohsari et al., 2015; Loh et al., 2020; Shatu

et al., 2019), and speculatively, place attachment may affect this relationship. Improving the urban design of neighbourhoods to make them supportive of physical activity may provide more opportunities for people to develop stronger attachments to place (especially for those who prefer to be physically active). Research is needed to examine the links between the actual (objective) built environment and place attachment. Moreover, interventions to improve people's perceptions of their neighbourhood's supportiveness for physical activity, mainly education approaches (e.g., providing neighbourhood maps with routes, recreational destinations, and landmarks) have been proposed when changes to the built environment may not be feasible (Rosenberg et al., 2009). Our findings might suggest that strategies for encouraging people to form stronger emotional attachments and bonds with their neighbourhoods could potentially improve perceptions and physical activity. When modifying the built environment is not possible, improving place attachment might be facilitated through the offering of local events or initiatives that encourage people to not only interact and become more familiar with their neighbourhood surroundings (e.g., organized nature walks or park-based activities) but also through encouraging social and community engagement (i.e., forging friendships and building trust), improving a sense of safety, and creating a sense of community (Dang et al., 2022; Lestari and Sumabrata, 2018; Manzo and Perkins, 2006; Ujang et al., 2018).

This study had several limitations. We cannot infer causal relationships between variables, because the design of this study was cross-sectional. The physical activity measure was self-reported and may be subject to recall bias. While providing participants with a definition of neighbourhood (an area within 10 to 15-minute walking distance from home) for place attachment, walkability, and physical activity items allowed these measures to be contextually congruent, participants' perceived neighbourhood boundaries may differ

(Pinchak et al., 2021). The N-IPAQ restricted our analysis to include physical activity within the neighbourhood. It is possible that those with low place attachment or those who perceived their neighbourhood to be less walkable accumulated physical activity outside their neighbourhoods. Additionally, our analysis included data from a dataset a decade old. This dataset, while dated, provided a rare opportunity to examine the associations between place attachment, perceived walkability, and physical activity. Strengths of this study included the context-matched and behaviour-specific measures of place attachment, perceived walkability, and physical activity and the use of established (reliable) tools for measuring them. This study also benefits from having a random sample and participants from various neighbourhoods with different urban designs (McCormack et al., 2021; McCormack et al., 2014), which increases the built environment exposure variability (Koohsari et al., 2020). Conducting a formal mediation test to explore the pathways between place attachment and walking was a novel aspect of this study.

5. Conclusions

This study found that place attachment dimensions were positively associated with walking for transport and recreation. These associations with walking for transport were mediated by perceived neighbourhood walkability. Despite being based on cross-sectional data, the findings provided behavioural insights that the built environment is a determinant of walking (at least walking for transport). Importantly, our findings suggest that place attachment appears to be a relevant correlate of neighbourhood based physical activity and thus research should consider place attachment when investigating relationships between the built environment and physical activity.

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Table 1. Place attachment dimensions included in this study (Williams and Vaske, 2003)

	Question Items
Place identity	1- I feel neighbourhood is part of me. 2- Neighbourhood is special to me. 3- I identify strongly with neighbourhood. 4- I am very attached to my neighbourhood. 5- Being physically active in or around my neighbourhood says a lot about who I am. 6- Neighbourhood means a lot to me.
Place dependence	1- Neighbourhood is best place for the types of activity I like to do. 2- No other place can compare to my neighbourhood for the physical activity I like to do. 3- I get more satisfaction out of being active in my neighbourhood than anywhere else. 4- Participating physical activity in neighbourhood is more important to me than being active anywhere else. 5- I wouldn't substitute any other area for doing the types of things I do in neighbourhood. 6- Physical activity I do in my neighbourhood I would enjoy just as much if I did it in another setting.

Note. Neighbourhood was an area within 10-to-15-minute walking distance from home.

Table 2. Characteristics of study participants (N= 1,800)

Variable	Mean (SD) or N (%)
Age (mean)	50.2 (15.2)
Gender	
Female	1128 (62.7)
Men	672 (37.3)
Education	
High school or less	528 (29.3)
College	465 (25.8)
University	807 (44.8)
Annual gross household income	
<$60 000/year	541 (30.1)
$60 000–119 999/year	580 (32.2)
≥$120 000/year	528 (29.3)
Don't know/refused	151 (8.4)
Marital status	
Married/living together	1257 (69.8)
Single/divorced/separated	543 (30.2)
Children at home <18 years of age	
No child	1189 (66.1)
At least one child	611 (33.9)
Length of residence (mean)	12.8 (12.1)

Self-rated health	
Poor/fair	264 (14.7)
Good	745 (41.4)
Very good	608 (33.8)
Excellent	183 (10.2)
Walking for transport (min/week)	108.4 (118.2)
Participation in walking for transport (per week)	746 (41.4)
Walking for recreation (min/week)	163.3 (155.9)
Participation in walking for recreation (per week)	1024 (56.9)
Vigorous physical activity (min/week)	151.1 (139.4)
Participation in vigorous physical activity (per week)	513 (28.5)
Place identity	2.8 (0.69)
Place dependence	2.3 (0.59)
Place attachment (overall)	2.6 (0.57)

			Direct effect	*Indirect effect*	*Total effect*
Effect mediation by perceived walkability	**Coefficient (95% CI)**	**Coefficient (95% CI)**	**Coefficient (95% CI)**	**Coefficient (95% CI)^**	**Coefficient (95% CI)**
Place identity -> NWT	0.15 (0.11, 0.19)*	0.25 (0.07, 0.43)*	0.03 (-0.08, 0.14)	0.04 (0.01, 0.07)*	0.06 (-0.04, 0.17)
Place identity -> NWR	0.14 (0.10, 0.17)*	0.07 (-0.08, 0.23)	0.10 (0.01, 0.20)*	0.01 (-0.01, 0.03)	0.11 (0.03, 0.20)*
Place identity -> NVIGPA	0.14 (0.09, 0.18)*	-0.12 (-0.33, 0.09)	0.03 (-0.09, 0.15)	-0.02 (-0.05, 0.01)	0.01 (-0.10, 0.13)
Place dependence -> NWT	0.11 (0.06, 0.16)*	0.22 (0.04, 0.40)*	0.15 (0.02, 0.27)*	0.02 (0.00, 0.05)*	0.17 (0.05, 0.30)*
Place dependence -> NWR	0.12 (0.08, 0.17)*	0.05 (-0.10, 0.20)	0.23 (0.13, 0.33)*	0.01 (-0.01, 0.03)	0.24 (0.14, 0.34)*
Place dependence -> NVIGPA	0.11 (0.05, 0.16)*	-0.13 (-0.33, 0.07)	0.07 (-0.06, 0.20)	-0.01 (-0.04, 0.01)	0.05 (-0.07, 0.18)
Place attachment (overall) -> NWT	0.17 (0.12, 0.22)*	0.22 (0.04, 0.41)*	0.10 (-0.03, 0.24)	0.04 (0.01, 0.07)*	0.14 (0.01, 0.27)*
Place attachment (overall) -> NWR	0.18 (0.14, 0.22)*	0.04 (-0.12, 0.20)	0.22 (0.12, 0.33)*	0.01 (-0.02, 0.04)	0.23 (0.13, 0.34)*
Place attachment (overall) -> NVIGPA	0.16 (0.10, 0.22)*	-0.13 (-0.33, 0.08)	0.06 (-0.08, 0.20)	-0.02 (-0.06, 0.01)	0.04 (-0.10, 0.18)

NWT: Neighbourhood walking for transport (log) minutes per week; n = 746
NWR: Neighbourhood walking for recreation (log) minutes per week; n = 1024
NVIGPA: Neighbourhood vigorous physical activity (log) minutes per week; n = 513
^95% CI based on standard errors estimated from Monte-Carlo simulations (5000 repetitions). Other CIs estimated using robust standard errors.
[a] According to the Zhao, Lynch & Chen's approach to testing mediation
*$p<0.05$

	NWP		NWR		
	OR[1] (95% CI)	**OR[2] (95% CI)**	**OR[1] (95% CI)**	**OR[2] (95% CI)**	**OR[1] (95% CI)**
Place identity	1.23 (1.06, 1.42)*	1.04 (0.89, 1.21)	1.70 (1.47, 1.97)*	1.66 (1.42, 1.93)*	1.39 (1.18, 1.65
Perceived walkability		3.49 (2.64, 4.62)*		1.21 (0.94, 1.58)	
Place dependence	1.46 (1.23, 1.73)*	1.26 (1.05, 1.51)*	1.90 (1.59, 2.26)*	1.84 (1.54, 2.20)*	2.13 (1.75, 2.58
Perceived walkability		3.32 (2.51, 4.38)*		1.24 (0.96, 1.61)	
Place attachment (overall)	1.43 (1.19, 1.72)*	1.17 (0.96, 1.41)	2.12 (1.77, 2.55)*	2.07 (1.71, 2.50)*	1.97 (1.60, 2.42
Perceived walkability		3.36 (2.54, 4.45)*		1.15 (0.89, 1.50)	

n = 1800

[1] Model adjusted for all covariates (age, gender, education, income, marital status, children at home, length of residence, and self-rated health)

[2] Model adjusted for perceived walkability plus all covariates

*$p<0.05$

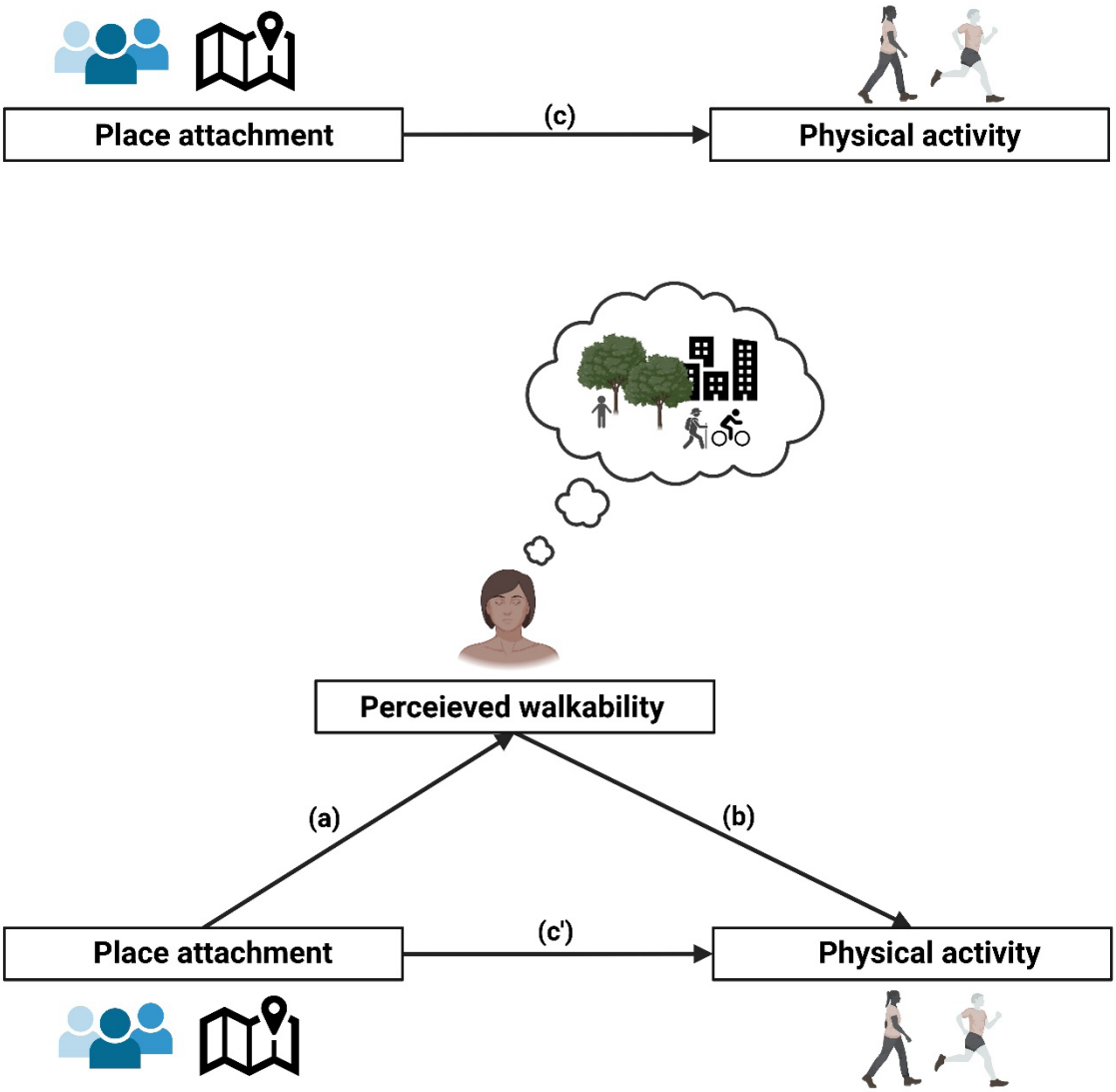

Figure 1. The conceptual framework of this study